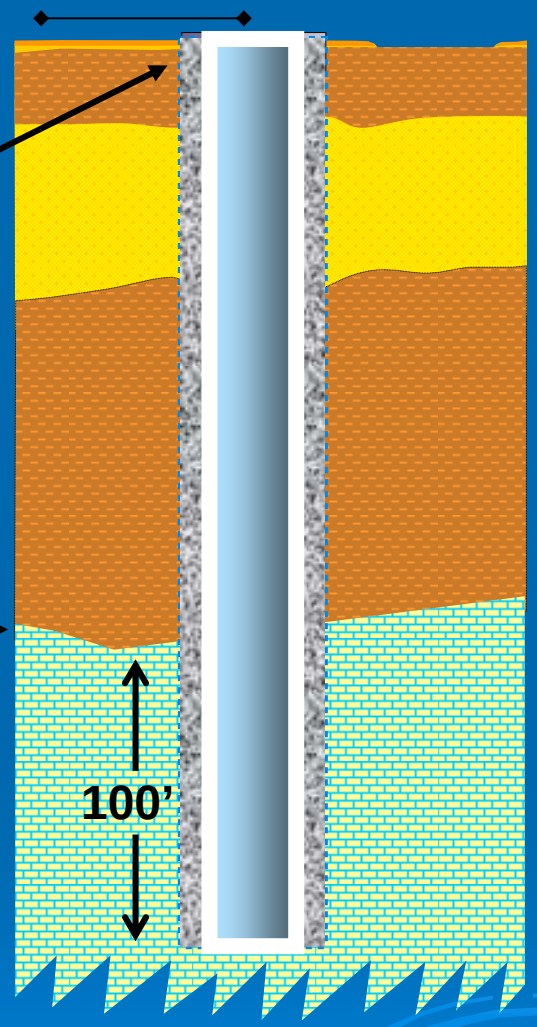
Regulatory Response to Hydraulic Fracturing in Michigan

Michigan Department of Environmental Quality
Resource Management Division
Office of Oil, Gas, and Minerals

OOGM's Role

- The DEQ, Office of Oil, Gas, and Minerals (OOGM) Regulates the Following:
  - Permitting (Well Site Selection, Isolation Distances, Soil Erosion and Control, Casing and Sealing Programs Blowout Prevention, etc.)
  - Drilling & Completion (Casing and Sealing Programs, Blowout Prevention, Lined Reserve Pits, HydroFrac Water Management, Site Restoration, etc.)
  - Production (Approval of Secondary Containment Plans, Flowline Pressure Testing, Groundwater Monitoring, Response and Remediation of Spills)
  - Plugging and Final Site Restoration

Surface Casing

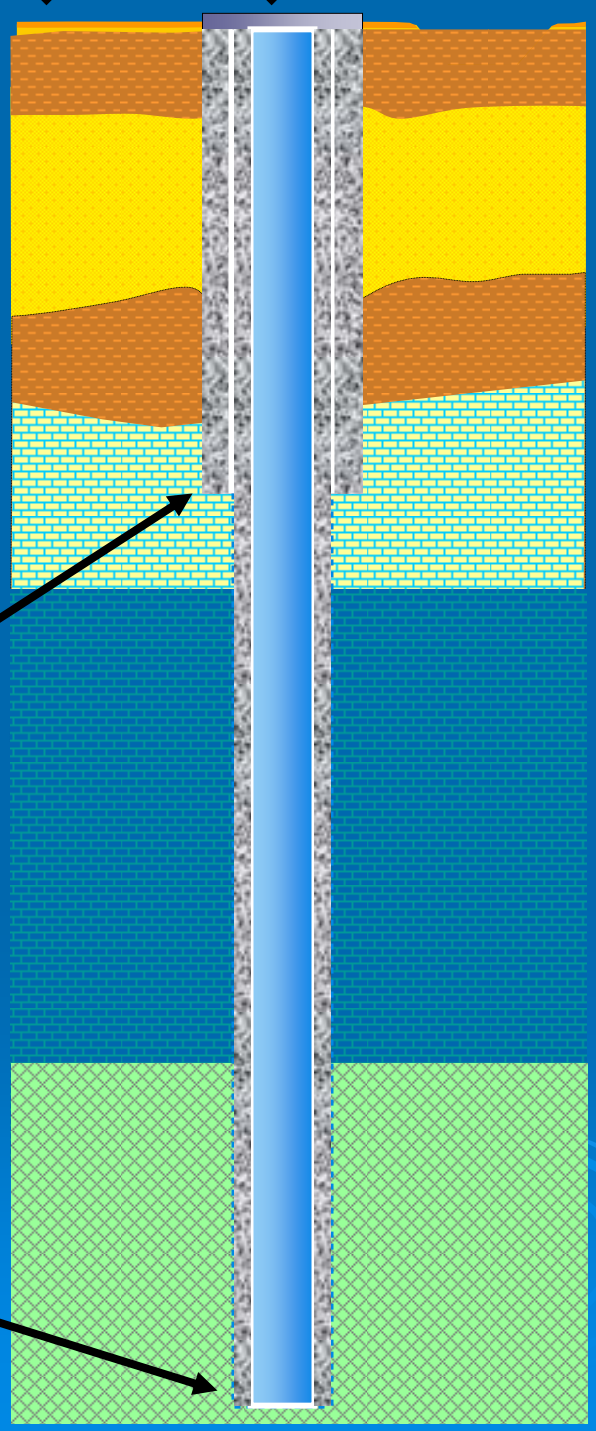


Conductor Pipe

Base of fresh water
Top of bedrock

At least 100 feet into bedrock and at least 100 feet below all freshwater zones

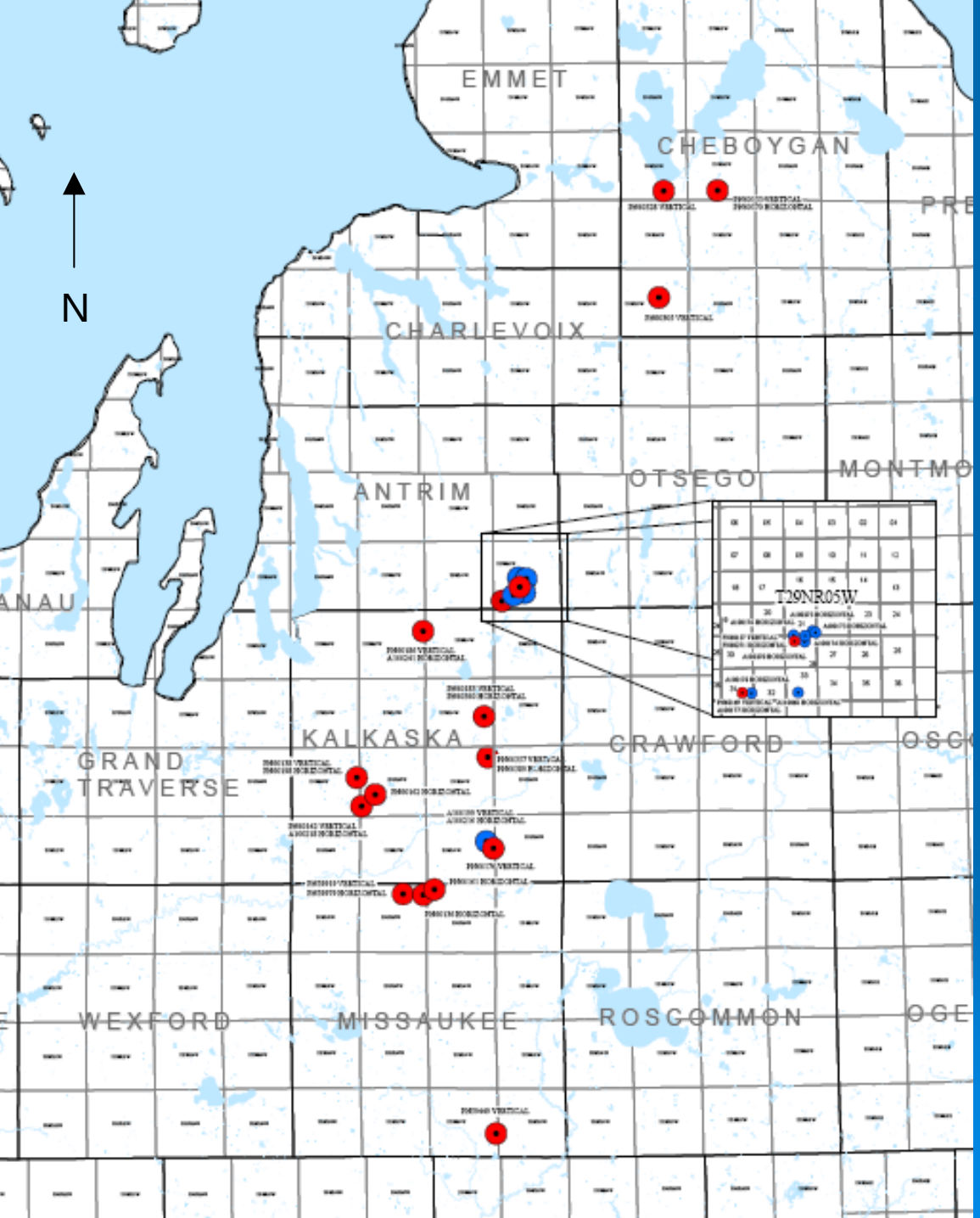
Intermediate Casing



Base of Surface Casing

Base of Intermediate Casing

Current Collingwood / Utica Permits and Applications



Legend

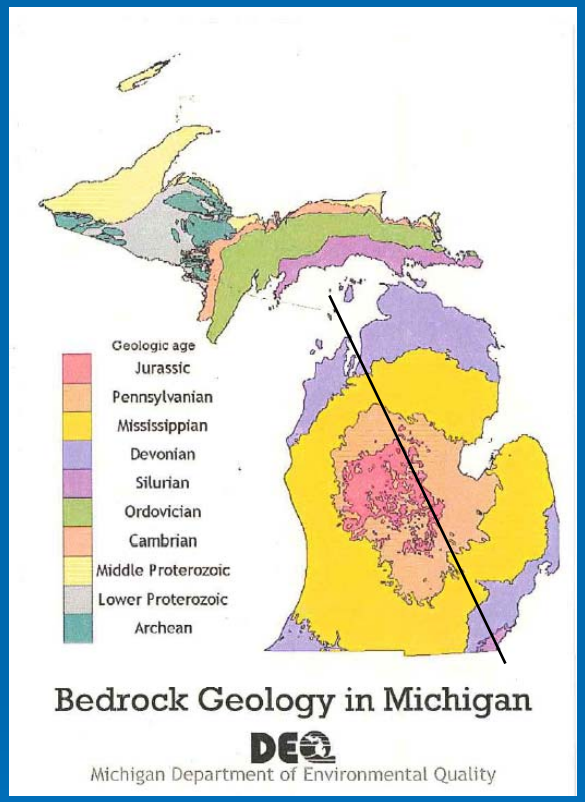
- Issued Permits (20)
- Pending Applications (12)

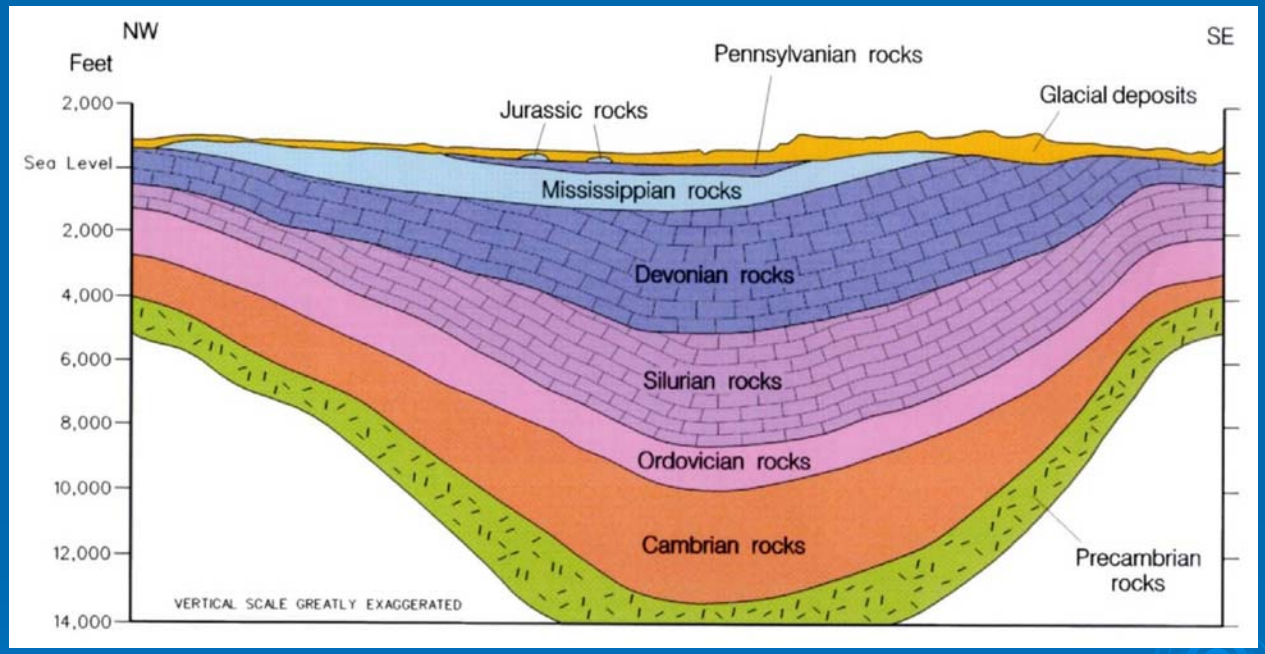
Map updated 9/14/11

Utica & Collingwood Geology

- Utica Shale
  - True shale
  - Compacted clay with minor silt and carbonate
  - Light to dark gray or occasionally black
  - Organic content ranges from 0.5% to 1.3% by weight
- Collingwood
  - Fine-grained limestone interbedded with shelly limestone of Upper Trenton
  - Black
  - Organic content ranges from 2.5% to 6.0% by weight

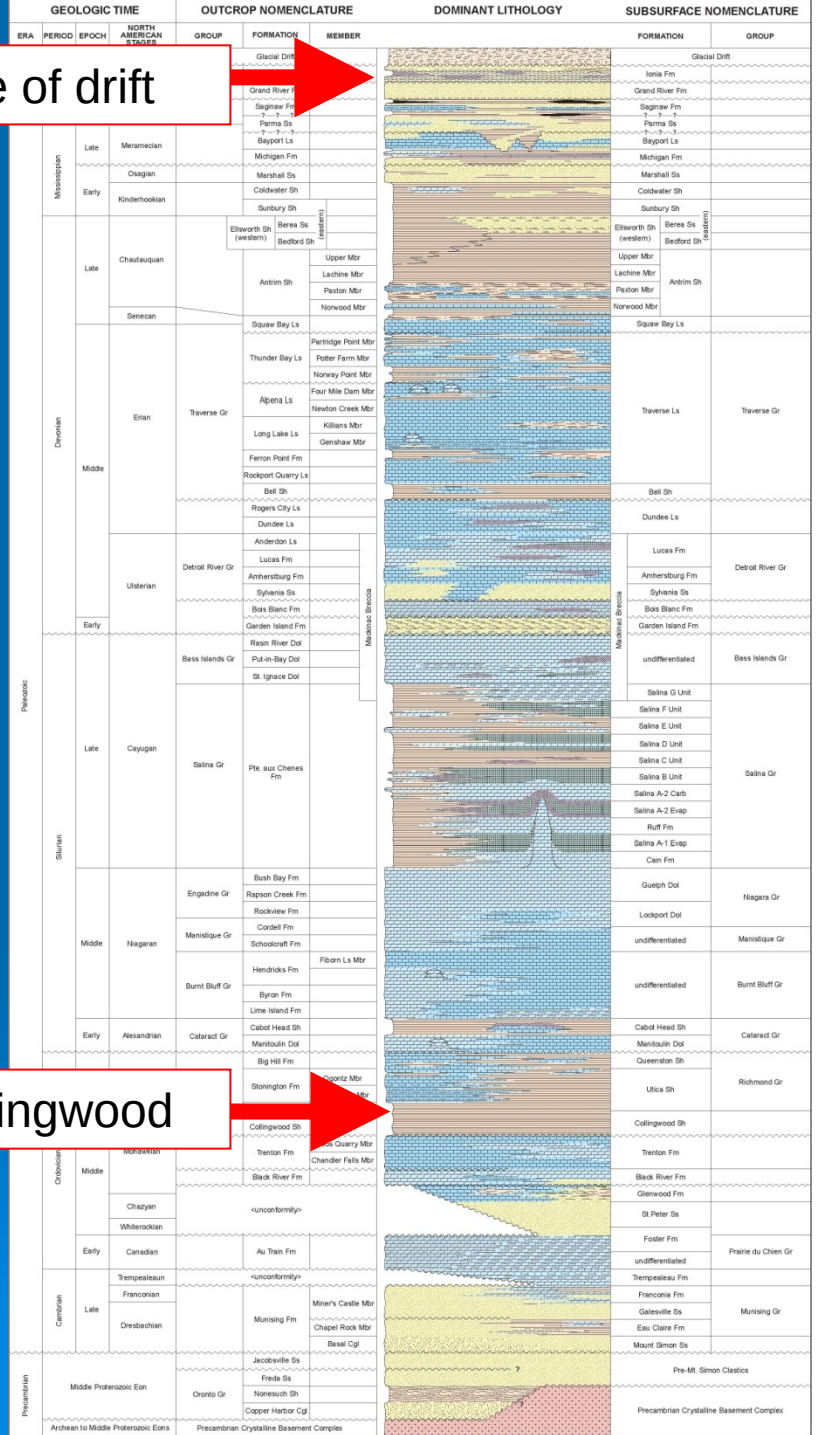
Michigan Basin Geology





Base of drift

Utica-Collingwood



STRATIGRAPHIC NOMENCLATURE FOR MICHIGAN

Michigan Dept. of Environmental Quality
Geological Survey Division
Harold Fitch, State Geologist
and
Michigan Basin Geological Society

Stratigraphic Nomenclature Project Committee:
Dr. Paul A. Catacosinos, Co-chairman
Mr. Mark S. Wollensak, Co-chairman

Principal Authors:
Dr. Paul A. Catacosinos
Dr. William B. Harrison III
Mr. Robert F. Reynolds
Dr. David B.Westjohn
Mr. Mark S. Wollensak

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Acknowledgements

This work is the product of the combined efforts of the geological communities of Michigan and the surrounding states and provinces. Below are given just a representative few of the contributors:

Academia: Dr. Aureal T. Cross, Michigan State University; Dr. Robert H. Dott, Jr., University of Wisconsin; Mr. William D. Everham, Ph.D. Candidate, Michigan Technological University.

Government: Dr. Terry R. Carter, Ontario Ministry of Natural Resources; Mr. John M. Esch, Michigan Department of Environmental Quality; Dr. Brian D. Keith, Indiana Geological Survey; Mr. Lawrence H Wickstrom, Ohio Geological Survey.

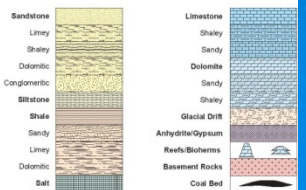
Industry: Mr. Donald J. Bailey, Consultant; Mr. Jimmy R. Myles, Scot Energy; Mr. Dan E. Pfeiffer, Pfeiffer Exploration Services.

A complete listing of all contributors will be found in the Stratigraphic Lexicon for Michigan, of which this column is an integral part.

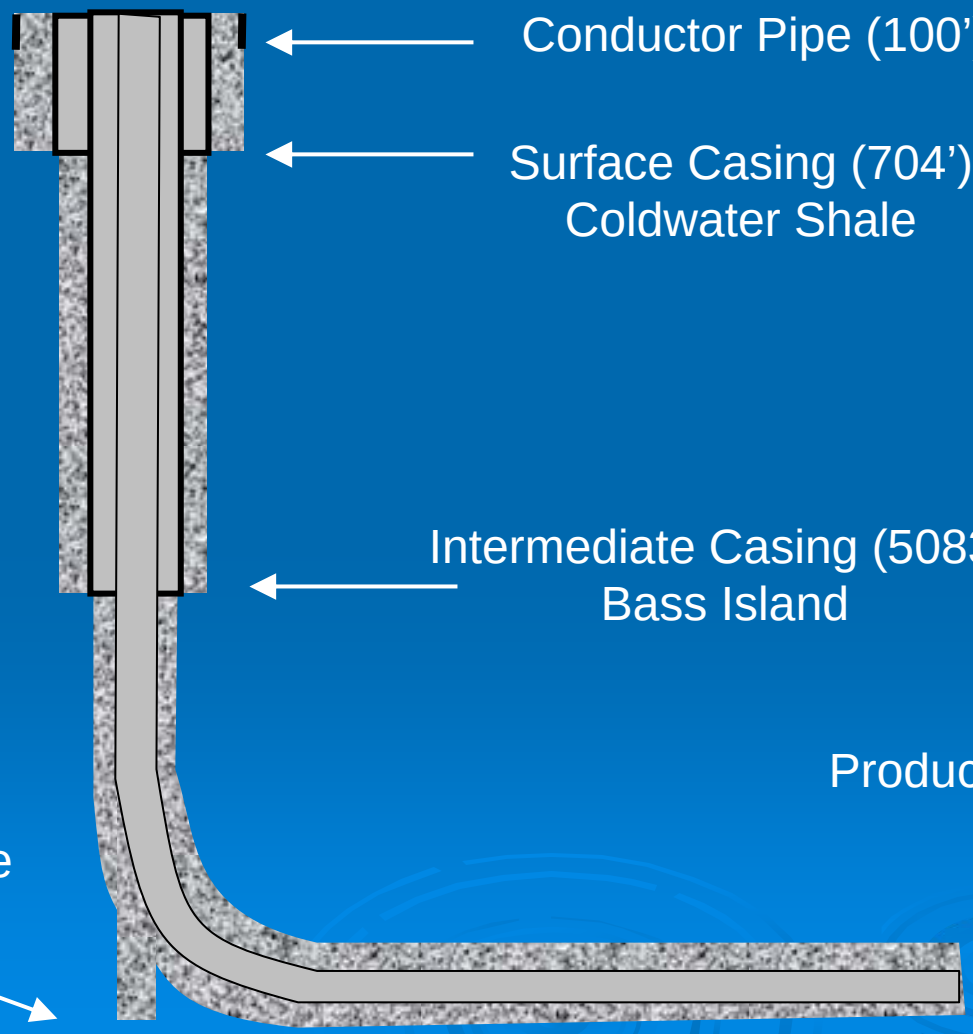
RELATED TERM CORRELATION

STRATIGRAPHIC POSITION	RELATED TERMS
Ionia Fm	Jurassic Red Beds
Michigan Fm	Clare Dolomite, Brown Lime, Stray Dolomite, Stray Sandstone, Stray-Stray Sandstone, Stray-Stray-Stray Sandstone, Triple Gyp
Coldwater Sh	Coldwater Red Rock, Speckled Dolomite, Wier Sand
Antrim Sh	Charlton Black Shale Member, Elitrim, Chester Black Shale Member, Upper Black Shale, Light Antrim, Lower Black, Lower Antrim Middle Antrim, Middle Gray Antrim, Dark Antrim, Middle Gray Shale, Unit 1A, Unit 1B, Unit 1C, Crappo Creek Grey Shale Member
Dundee Ls	Reed City Member/Dolomite/Anhydrite
Lucas Fm	Freer Sandstone, Horner Member, Iutzi Member, Massive Salt/Anhydrite, Sour Zone, Big Anhydrite, Richfield Zone/Member/Sandstone, Big Salt
Amherstburg Fm	Filer Sandstone, Meldrum Member, Black Lime
St. Ignace Dolomite	Salina H Unit
Salina B Unit	Big Salt, B Salt
Ruff Formation	Salina A-1 Carbonate, Rabbit Ears Anhydrite,
Cain Fm	Salina A-0 Carbonate
Guelph Dolomite	Brown Niagara, Niagaran Reef, Pinnacle Reef, Engadine Dolomite
Lockport Dolomite	Gray Niagara, White Niagara
Burnt Bluff Gr	Clinton Formation
Trenton Fm	Cap Dolomite
Black River Fm	Van Wert Zone, Sneaky Peak, Black River Shale
Glenwood Fm	Goodwell Unit, Zone of Unconformity
St. Peter Sandstone	Bruggers Sandstone, Jordan Sandstone, Knox Sandstone, Massive Sand
Prairie du Chien Gr	Foster Formation, New Richmond Sandstone, Lower Knox Carbonate, St. Lawrence Formation, T-PDC, Oneota Dolomite, Brazos Shale
Trempealeau Fm	Lodi Formation
Galesville Ss	Dresbach Sandstone
Pre-Mt. Simon Clastics	Precambrian "Red Beds"

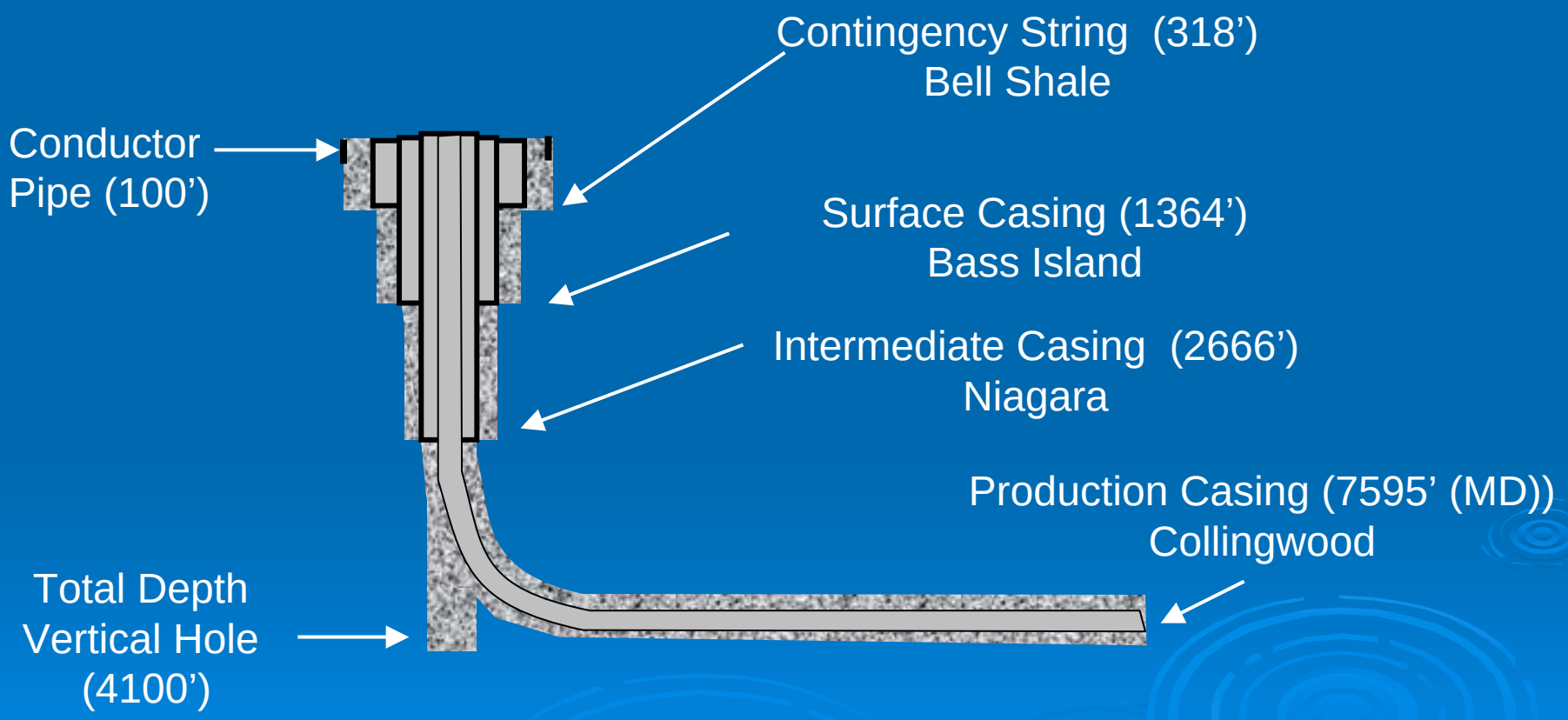
LEGEND



Drilling - Casing and Sealing
(Kalkaska / Missaukee Counties)

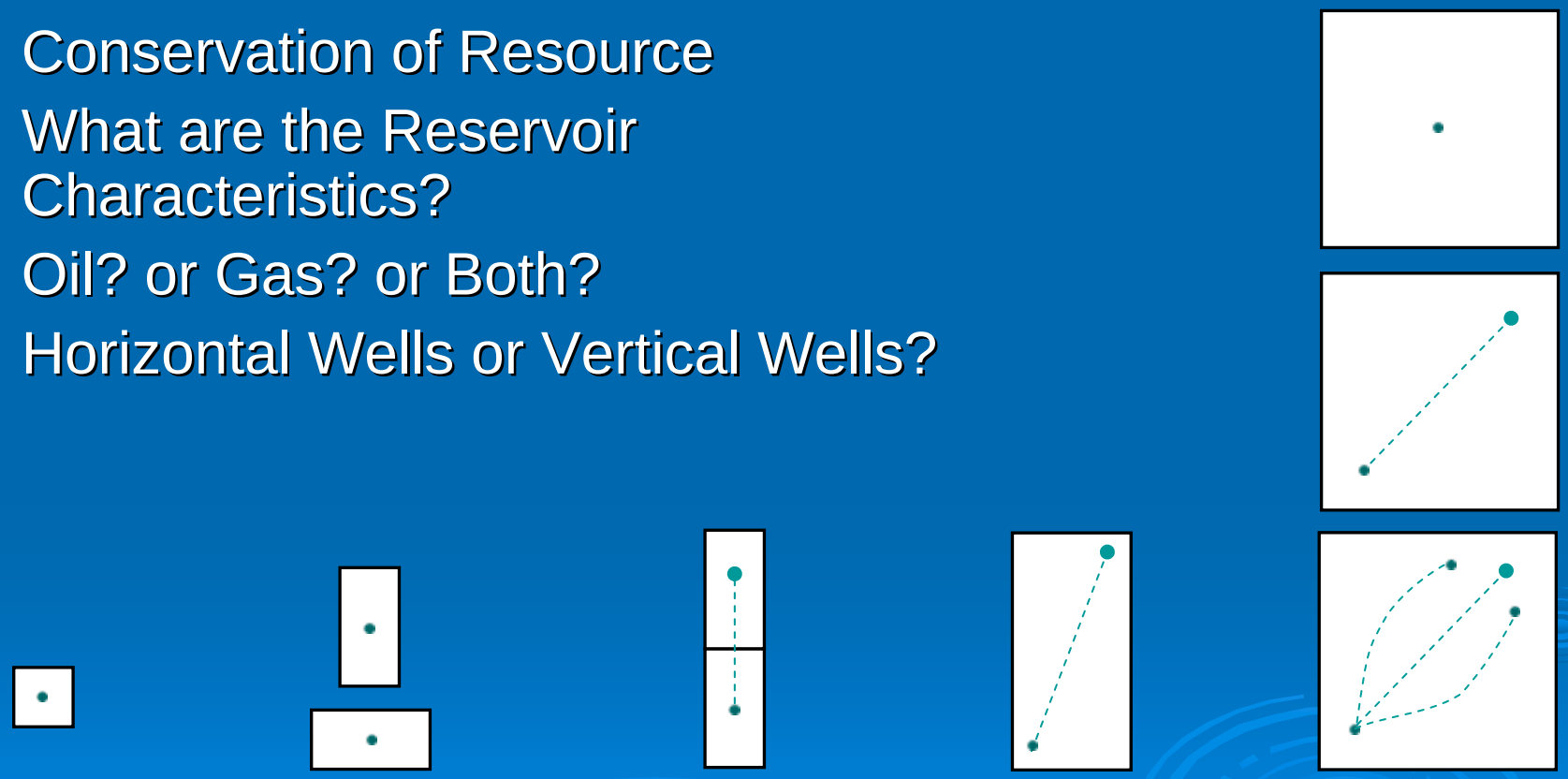


Drilling - Casing and Sealing
(Cheboygan County)



Collingwood Spacing Issues

- Conservation of Resource
- What are the Reservoir Characteristics?
- Oil? or Gas? or Both?
- Horizontal Wells or Vertical Wells?



40 acre spacing **80 acre spacing** **160 acre spacing** **320 acre spacing** **640 acre spacing**

Large Volume Hydraulic Fracturing Water Usage

- State Pioneer 1-3HD1

  (Utica-Collingwood discovery well, Missaukee County)

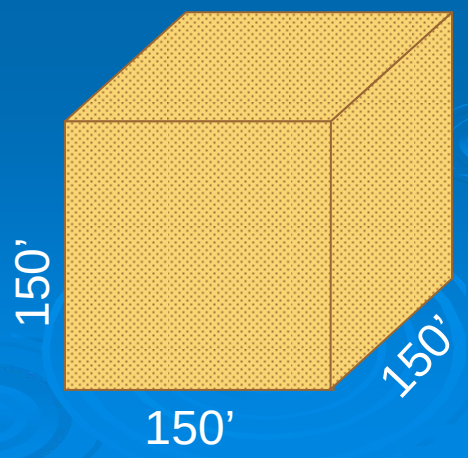
  - 160,000 barrels of water = 6,720,000 gallons
  - 15 stages
  - 448,000 gallons per stage

- Antrim Shale Well
  - 40,000 – 100,000 gallons
  - 3-4 stages

Large Volume Hydraulic Fracturing Water Usage

How Much is 6.7 Million Gallons?

- Equivalent to the volume of:
  - 3/8-inch of rainfall over one mi^2
  - 10 Olympic swimming pools
  - water in a ~150’ cube of sand aquifer (25% porosity)



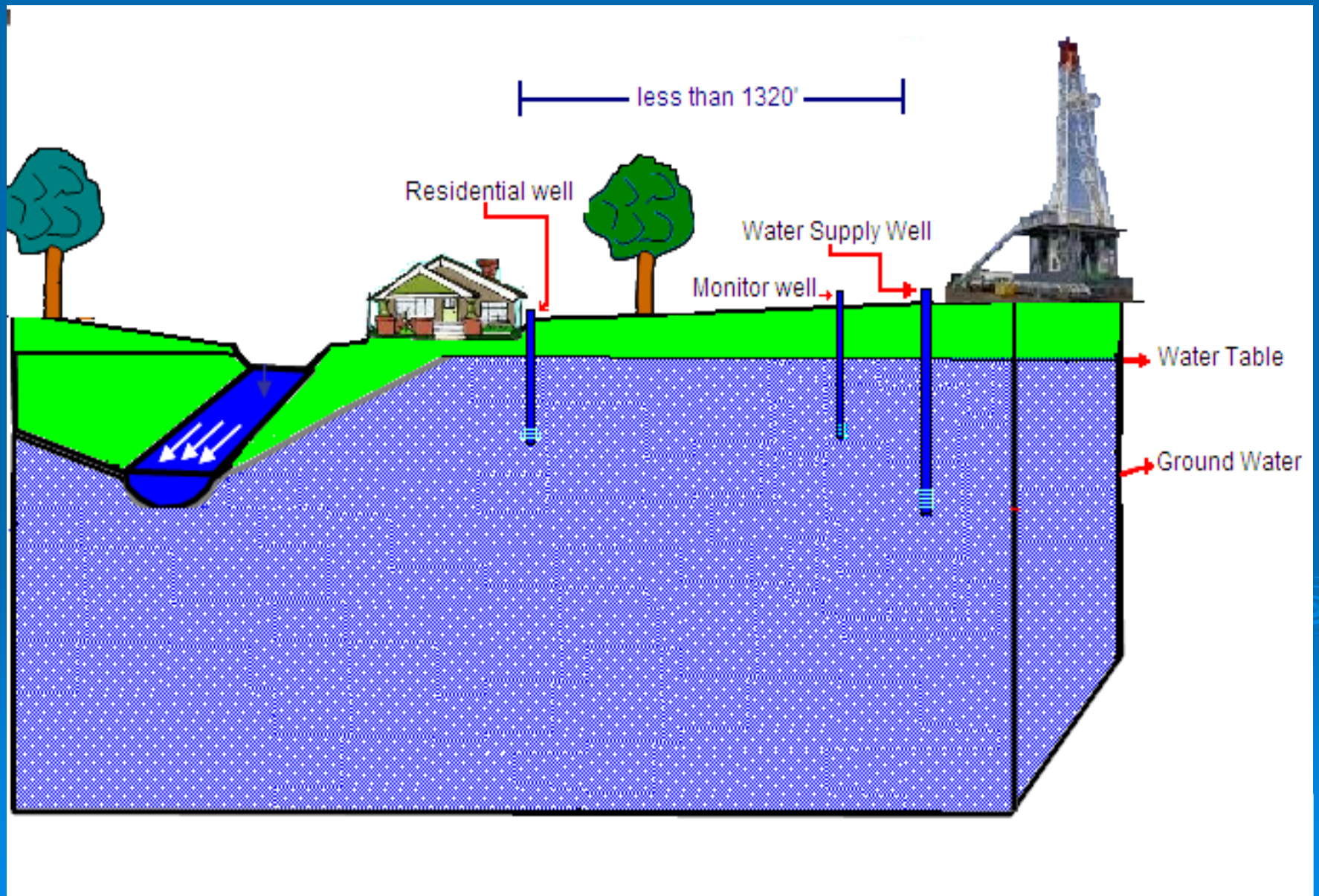
Supervisor of Wells Instruction 1-2011

- Definitions:
  - High volume hydraulic fractured well – uses over 100,000 gallons of water
  - Large volume water withdrawal – withdrawals with a cumulative total over 100,000 gallons per day over 30 consecutive days
  - Definitions used in Part 327, Great Lakes Preservation of Act 451 used in SOW 1-2011
- Permitting:
  - Use of the Water Withdrawal Assessment Tool
  - Additional data submission – volumes of water; number of water withdrawal wells, location, depth, rates, and aquifer type; other water wells; and freshwater pit

Supervisor of Wells Instruction 1-2011 cont.

- Completion:
  - Monitor well
  - Freshwater pit shall not create a “hazard”
  - Monitor and record injection pressures
- Reporting
  - Material Data Safety Sheets (MSDS)
  - Service company records
  - Annular pressures
  - Total volume of flowback water

Aquifer Monitoring



What is Hydraulic Fracturing?

- A procedure used to complete some oil or natural gas wells
- Pump water at high pressure to create fractures in rock that allow oil or natural gas to flow more freely to the well bore
- Proppants, usually silica sand, are added to the water to hold the fractures open once they are created

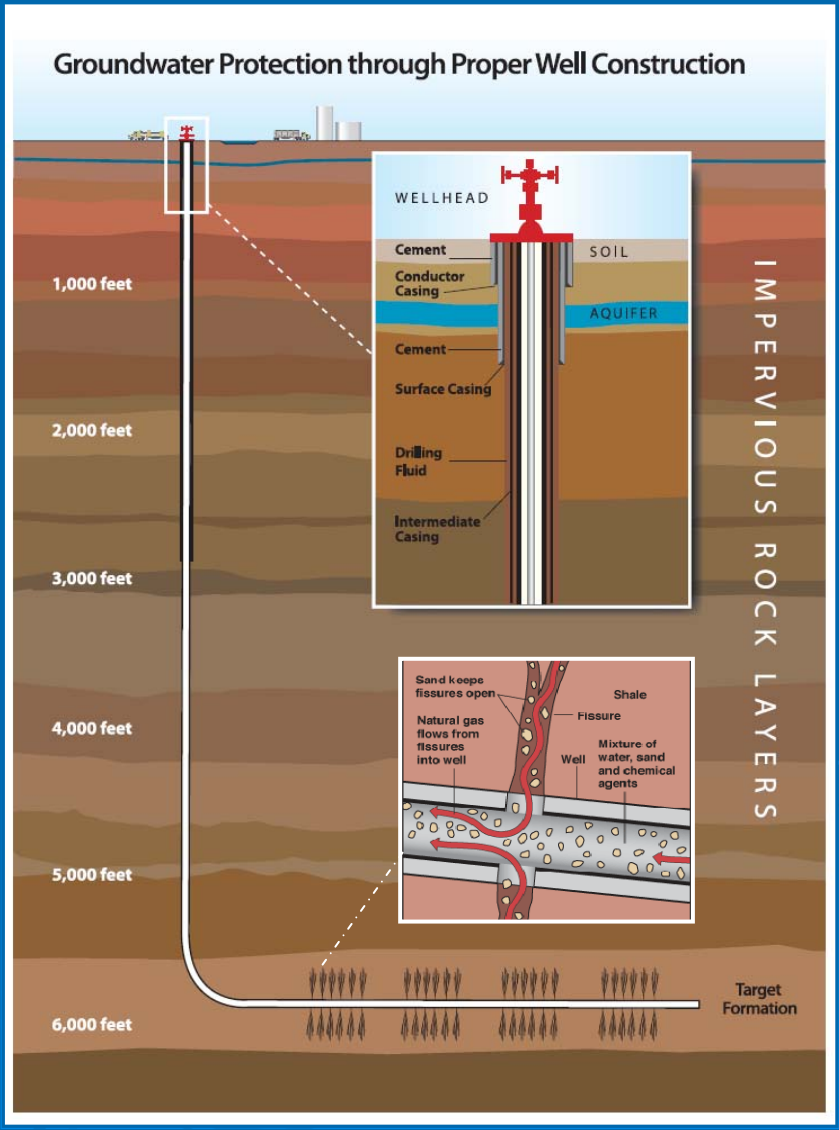


Image 7

History of Hydraulic Fracturing

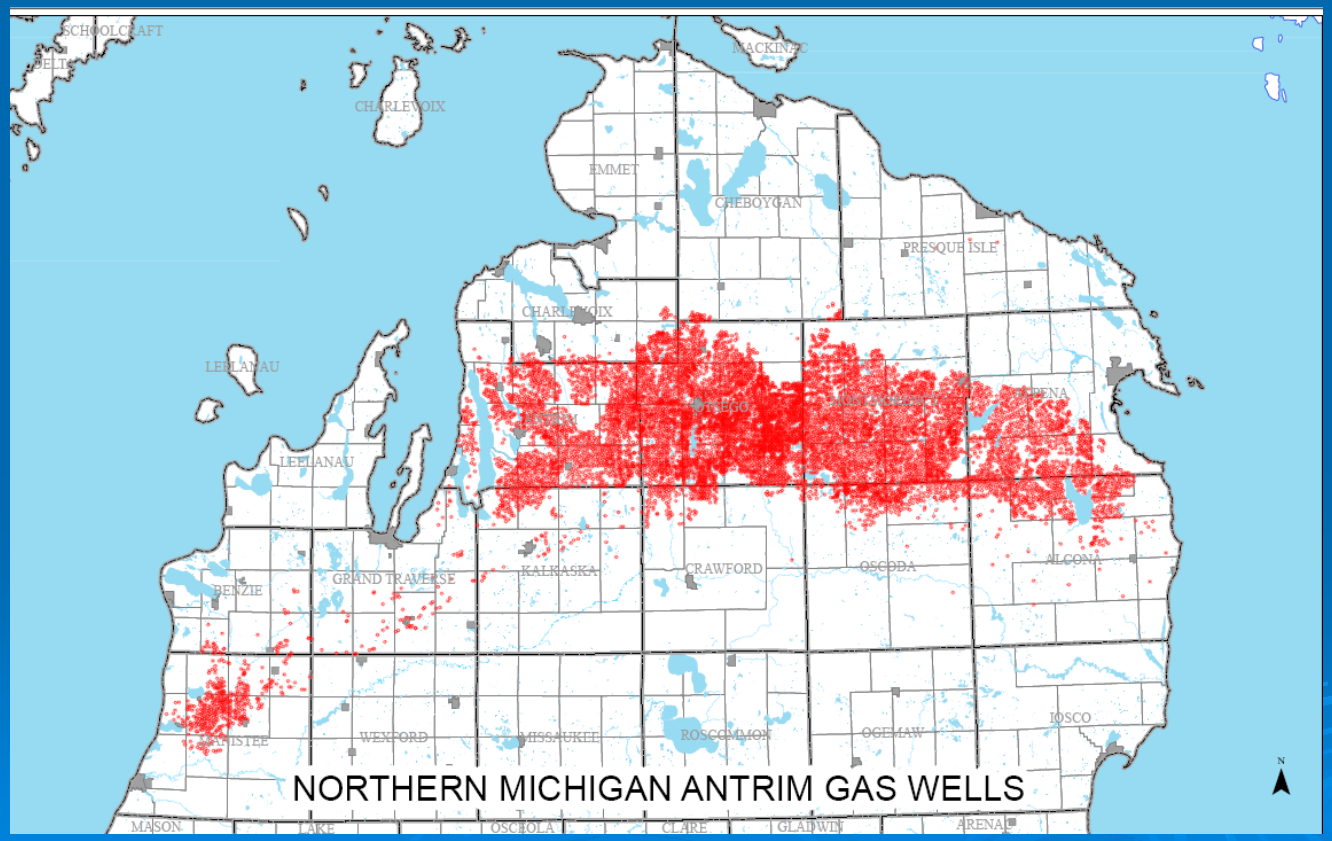
- Stanolind Oil first fractured a well in 1947
  - Klepper No. 1 Well in Kansas
- Halliburton Obtained License in 1949
- Next 60 yrs
  - Fluid Science Advances
  - Proppant Development
  - Rock Mechanics
  - Modeling & Simulation
  - Horizontal Well Integration

Hydraulic Fracturing in Michigan

- State Regulations
  - Casing and Sealing
  - Water Withdrawal
  - Water Storage & Disposal
  - Spill Reporting
    - Cleanup to Part 201
  - Chemicals Used
    - MSDS Sheets on Location and on Web
    - Legislation
  - Completion Plans
  - Monitored On-site by Staff

Hydraulic Fracturing in Michigan

- The first reported hydraulic fracturing in Michigan was in 1952 on a well in Elk Township, Lake County. The zone was 1088' - 1118' in the "Berea horizon" of the Ellsworth Shale.
- Since then ~12,000 Wells have been Hydraulically Fractured
  - The vast majority of these are vertical wells in the Antrim Shale. Completions are lower volume fracture jobs that are quite different than the high volume, horizontally drilled, Utica-Collingwood completions.



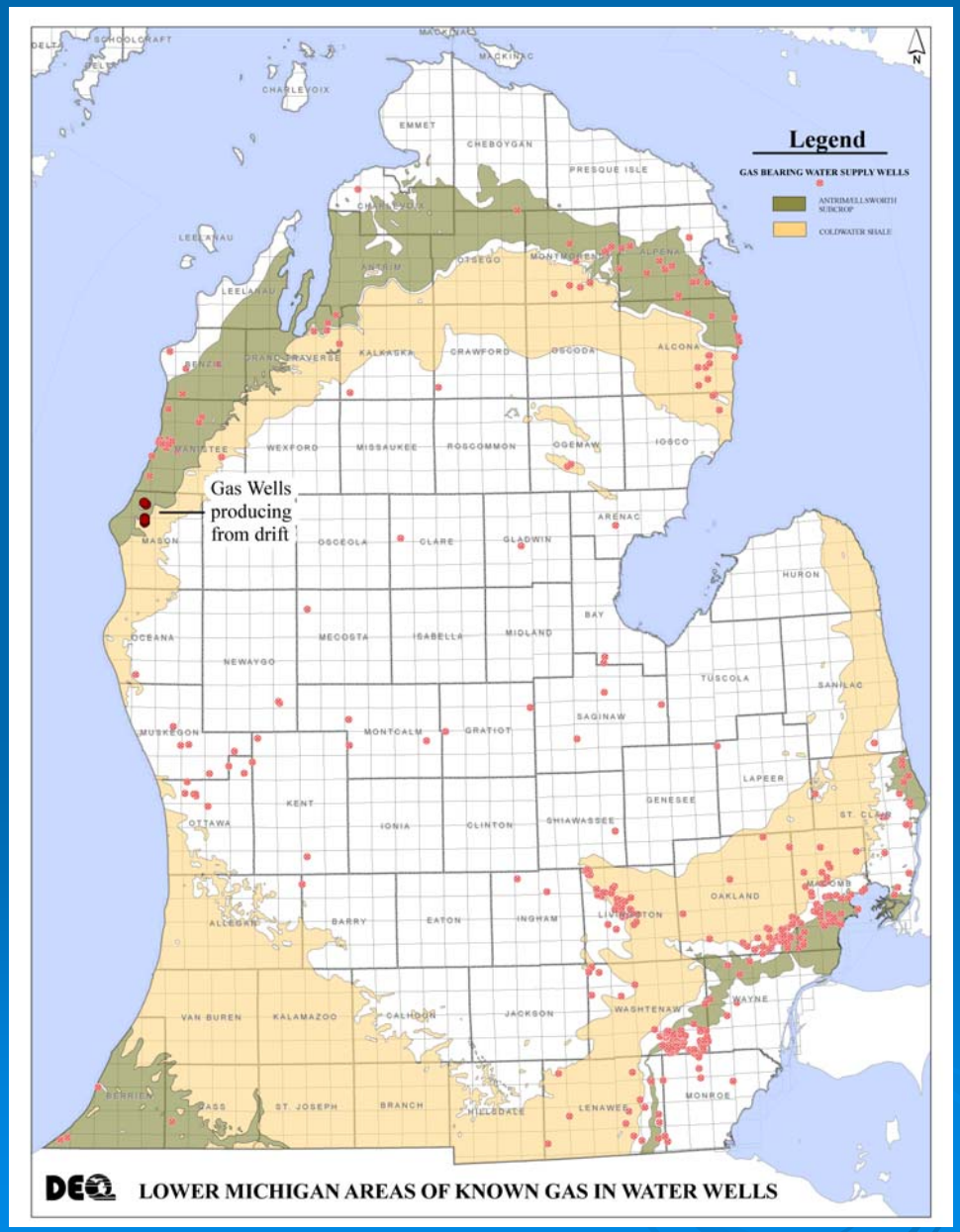
- No evidence of any adverse impacts to environment or public health.

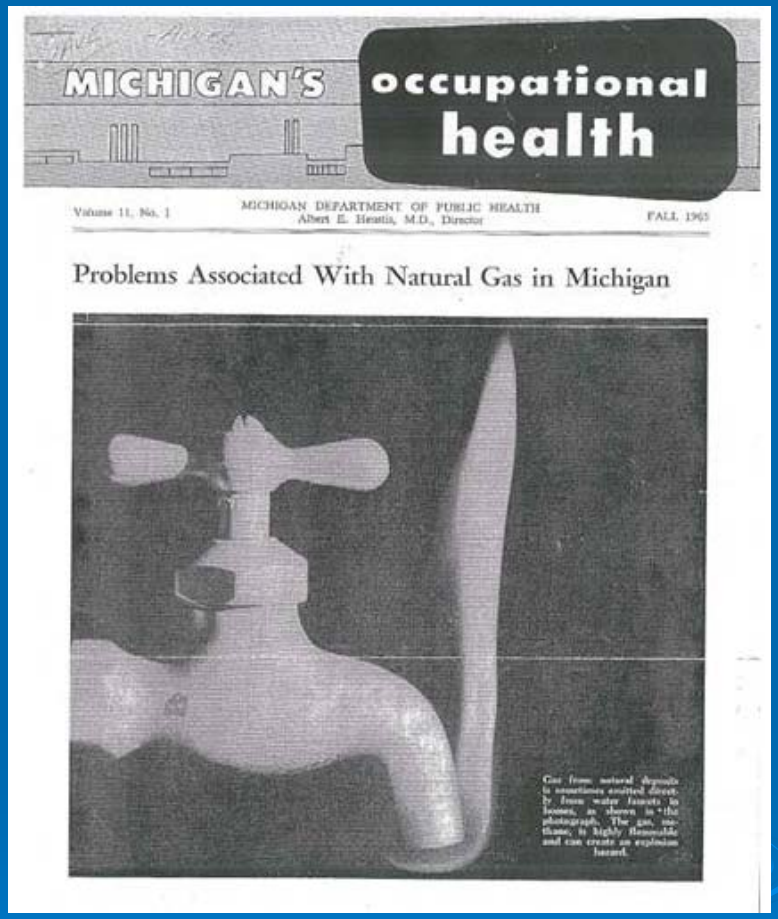
Hydraulic Fracturing

Hydraulic Fracturing
The Five Most Common Issues

- Migration of gas or fracture fluids
  - Site specific review of casing and sealing programs
- Identification of chemical additives
  - MSDS – post online ASAP –improve chemical disclosure
- Management of “flow back” water
  - No fluid to pits – deep well disposal - reporting
- Surface spills
  - Secondary containment & tanks instead of pits
- Water use
  - SOW Instruction 1-2011 – Use of WWAT – Monitor wells – reporting – MSDS – website

Naturally Occurring Gas in Water Wells





MICHIGAN'S occupational health

Volume 11, No. 1 — MICHIGAN DEPARTMENT OF PUBLIC HEALTH, Albert E. Heatis, M.D., Director — FALL 1965

Problems Associated With Natural Gas in Michigan

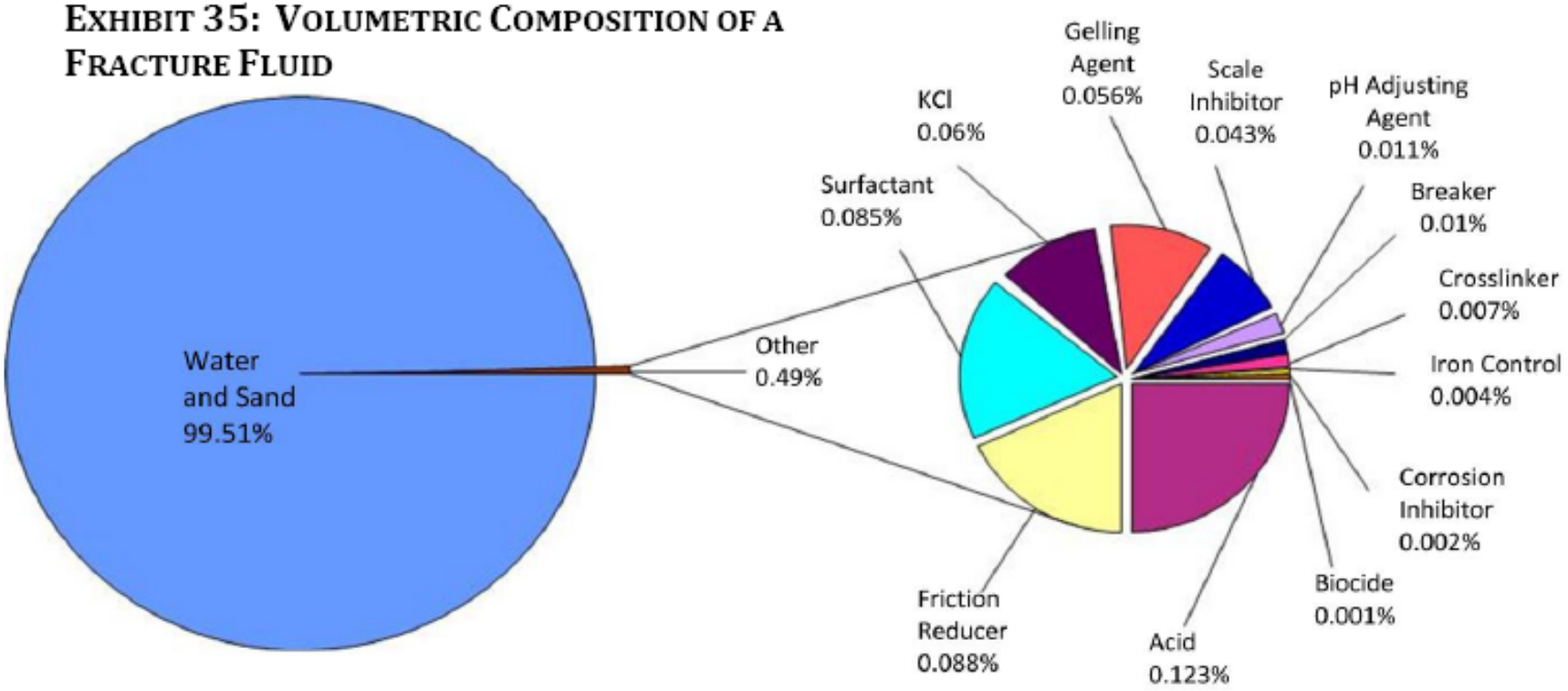
Gas from natural deposits is sometimes emitted directly from water faucets in homes, as shown in the photograph. The gas, methane, is highly flammable and can create an explosion hazard.

Has been reported in Michigan for a while (Article from 1965). Can occur when the aquifer is in connection with gas bearing shales or buried organics

What's in Frac Fluid?

MODERN SHALE GAS DEVELOPMENT IN THE UNITED STATES: A PRIMER

EXHIBIT 35: VOLUMETRIC COMPOSITION OF A FRACTURE FLUID



Source: ALL Consulting based on data from a fracture operation in the Fayetteville Shale, 2008

MSDS sheets for chemicals: http://www.michigan.gov/ogs

Management of ‘Flowback Water’

- Flowback Water or Produced Water
  - Water based fracturing fluid may be mixed with native water from the formation
  - Flows back through well casing to the wellhead when pumping pressure (of fracturing) has been relieved.
  - No fluid to pits – deep well disposal - reporting

Hydraulic Fracturing

Surface Spill Prevention

Recent Legislations Regarding Large Scale Water Withdrawals

- 2006 and 2008
  - Defines “Adverse Resource Impact”: “Stream’s ability to support characteristic fish populations is functionally impaired”
  - Defines Large Quantity Withdrawal (>100,000 gpd)
  - Provides for Registration of Water Withdrawals
  - Provides for an Internet Based Screening Tool – **“Water Withdrawal Assessment Tool”**
  - Water Withdrawal Regulations Part 327- Oil and Gas Development under Part 615 is exempt

The Water Withdrawal Assessment Tool

Intended for use prior to installing a new or increased large quantity withdrawal for the purpose of determining the potential impact to nearby water resources. Beginning February 28, 2006 all new withdrawals are prohibited from causing an adverse resource impact to the waters of the state. Beginning July 9, 2009 use of the assessment tool will be required of all new withdrawals prior to installation.

The Water Withdrawal Assessment Process

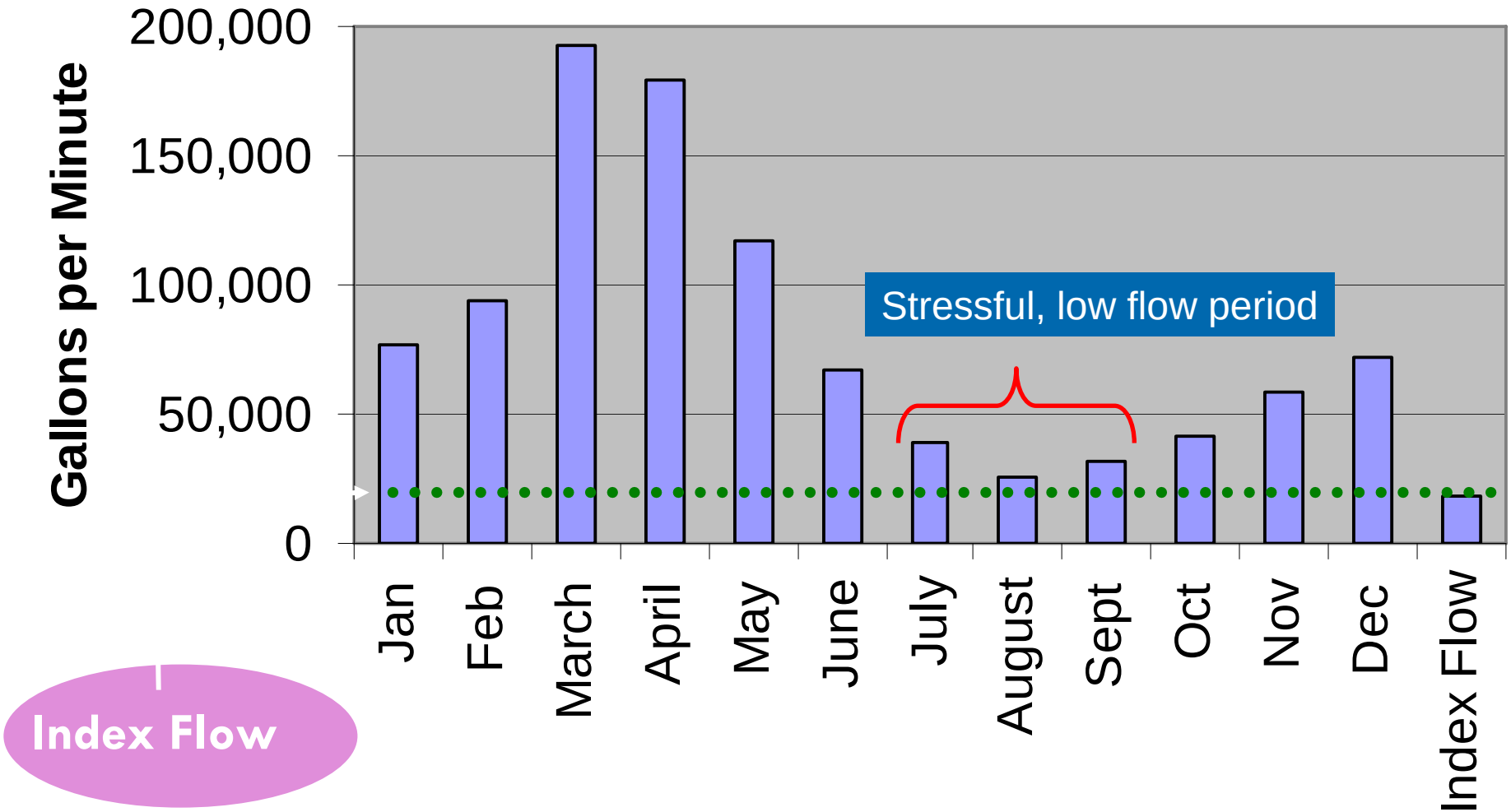
Groundwater —Feeds→ Stream Flow —Supports→ Fish Populations

- Three models interact within the impact assessment model
  - Withdrawal Model - How much water is in the aquifer, is being withdrawn, and from where and how it will affect stream flow
  - Stream Flow Model - How much water is flowing in the stream during summer low flow periods
  - Fish Impact Model - What fish are in the stream and what is the likely effect of removing water on those groups of fish

Characteristics of the Withdrawal Model

- Distance Matters
  - A well adjacent to a river will very quickly get water either from water that would have gone to the river or directly from the river
  - A well farther from a river will get more water from storage and require a longer time to affect the stream
- Geology and Soil Matters
  - Clay soils are “tight” and water does not move easily
  - Sandy soils are “porous” and water flows quickly

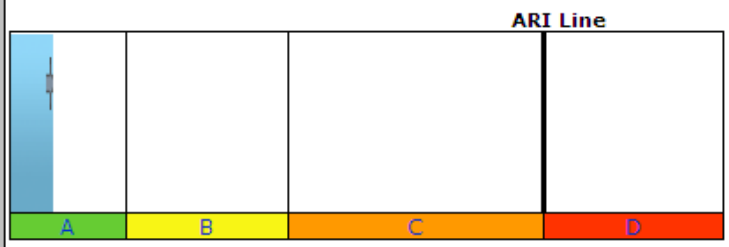
Looking Glass River near Eagle
Mean Monthly Flows



Water Withdrawal Screening Results

WARNING: For evaluation purpose only.

Adverse Resource Impact (ARI) Graph



The ARI graph above illustrates the estimated removal of water from a nearby stream and its potential for causing an adverse resource impact (ARI).

The proposed withdrawal has passed in Zone A.

Screening Results - PASSED

STREAM CLASSIFICATION: Warm stream

TEST VERSION RESULTS:
The proposed withdrawal would pass the screening process. The projected impact of the withdrawal lies within 'Zone A' and would not likely cause an adverse resource impact under the zones that become effective on February 1, 2009.

REGISTRATION:
A Large quantity withdrawal (LQW) with a capacity of 70 gpm or greater must be registered with the Michigan Department of Environmental Quality or with the Michigan Department of Agriculture if the LQW is for an agricultural purpose, before the withdrawal can begin. A registration is valid for 18 months. The withdrawal capacity must be installed within this time period or the registration becomes void. Registration may be done at this time through the button at the right.

You may come back to this site at a later time to register, or you may obtain a form to register the withdrawal by contacting Andrew LeBaron at 517-241-1435, or on-line at: www.michigan.gov/deqwateruse

Actions:

- Help
- Rerun
- Register Now
- Feedback
- View Google Map
- Print Report
- Exit

- Zones A, B, C, D are Set by Law
- Numerical Values are Different for Each Stream Type

OOGM's Water Withdrawal Analysis for High Volume Hydraulic Fracturing

- Review and evaluation of the potential for Adverse Resource Impacts (ARI) related to large volume water withdrawals for hydraulic fracturing is a two phase process.
  - Phase one is a preliminary screening process by the OOGM permitting and field staff during the permit application review.
  - Phase two is done by the operator using specific parameters for the water withdrawal needed for completion.
- **Under no circumstances will water withdrawals that are determined to create an actual ARI be approved.**

Summary & Looking Forward

- Regulatory Changes
  - Supervisors Instruction 1-2011 – Prevents ARI, monitors water levels, monitors hydraulic fracturing operations, chemical disclosure
  - Supervisors Letter 2011-1 – increases area of review for existing wells within a certain radius of hydraulically fractured wellbores.
- Looking Forward
  - EPA's Science Advisory Board (SAB) is conducting a study.
  - Public Outreach – http://www.michigan.gov/ogs
  - Hearing to determine Utica-Collingwood Spacing
  - In house DEQ-OOGM 'Utica-Collingwood Work Group'
  - Increased use of green eco-friendly chemistry
  - Review regulations and modify as needed to protect public health and the environment
  - Chemical disclosure